MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022 (2130)

PPH0036 – MODERN PHYSICS & THERMODYNAMICS

(Foundation in Engineering)

12 AUGUST 2022
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages (excluding front page, physical constant and formula list) with 3 Questions in Section A and 5 Questions in Section B.
2. Attempt **all** questions. The distribution of marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Instructions: Answer **ALL** Questions. Write your answers in the Answer Booklet.

SECTION A: (10 MARKS)

Question 1

Light may refract when propagates into a material where its speed is higher.

(a) Draw a diagram to illustrate this phenomenon. In the diagram, label the incident ray, the refracted ray, the incident angle, and the refracted angle, accordingly. [2.5 marks]

(b) State the refractive index condition (whether $n_1 > n_2$ or $n_1 < n_2$) for this phenomenon. [0.5 mark]

Question 2

In Figure AQ2, a setup of experiment is used to show the effect of light on metal.

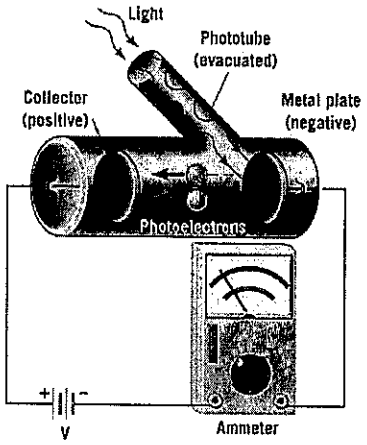

Figure AQ2

(a) Name this experiment. [1 mark]

(b) Sketch an I-V graph for two different intensities of light (Intensity A and Intensity B, where intensity A is higher than intensity B). Label accordingly. [2 marks]

Question 3

When a hot object warms a cooler object, does temperature flow between them? Are the temperature changes of the two objects equal? Explain your answer. [4 marks]

Continued...

SECTION B: (40 MARKS)

Question 1

(a) Standing wave on a string is: $D(x,t) = (0.8)\sin\left(\frac{\pi}{4}x\right)\cos(25\pi t)$

where D and x are in centimeters and t is in seconds.

Determine the amplitude and the wavelength of the interfering waves. [3 marks]

(b) A standing wave is established in a 100 cm long string fixed at both ends. The string vibrates in four segments when driven at 25Hz. Determine the wavelength and the speed of the wave through the string. [2 marks]

(c) Two loudspeakers on a concert stage are vibrating in phase. A listener is 51.4 m from the left speaker and 37.0 m from the right one. The listener can respond to all frequencies from 20 to 20000 Hz, and the speed of sound is 343 m/s. What is the lowest frequency that can be heard loudly due to constructive interference? [2 marks]

(d) An observer stands by the roadside of a straight road. An ambulance fitted with a 300 Hz siren moves toward the observer at a constant speed of 27.8 m/s. Determine the frequency of sound heard by the observer when

(i) the ambulance approaches him [1.5 marks]
(ii) the ambulance recedes him [1.5 marks]

Question 2

(a) An object is placed 20.0 cm to the left of a diverging lens (f = – 8.00 cm). A concave mirror (f = 12.0 cm) is placed 30.0 cm to the right of the lens (Figure BQ2).

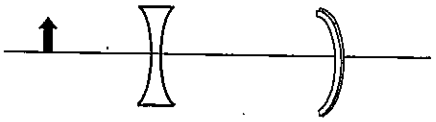

Figure BQ2

(i) Find the final image distance, measured relative to the mirror. [3 marks]
(ii) Is the final image real or virtual? [1 mark]

(b) When a grating is used with light that has a wavelength of 621 nm, a third-order maximum is formed at an angle of 18.0°. How many lines per centimeter does this grating have? [3 marks]

Continued...

Question 3

(a) Molybdenum has a work function of 4.20 eV. If the incident light has a wavelength of 180 nm, calculate

(i) the maximum kinetic energy for the photoelectrons, [2 marks]

(ii) the stopping potential. [2 marks]

(b) A photon is emitted as a hydrogen atom undergoes a transition from the n = 6 state to the n = 2 state. Determine the energy and the wavelength of the emitted photon. [3 marks]

Question 4

(a) Complete the following decay process by filling up the blanks.

(i) $^{211}_{82}\text{Pb} \rightarrow {}^{211}_{83}\text{Bi} + ____$ [1 mark]

(ii) $^{231}_{90}\text{Th}^{*} \rightarrow {}^{231}_{90}\text{Th} + ____$ [1 mark]

(iii) $^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + ____$ [1 mark]

(b) Refer to the following nuclear reaction:

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3{}^{1}_{0}\text{n}$$

(i) Name this type of nuclear reaction [1 mark]

(ii) What is the energy released in this nuclear reaction. (Assume the initial kinetic energy of the neutron is very small)

Nuclide	Mass
$^{235}_{92}\text{U}$	235.0439 u
$^{141}_{56}\text{Ba}$	140.9144 u
$^{92}_{36}\text{Kr}$	91.9263 u
$^{1}_{0}\text{n}$	1.0087 u

[3 marks]

(c) The radioactive isotope $^{241}_{95}\text{Am}$, with a half-life of 432 years, is the active element in many smoke detectors. Suppose such a detector will no longer function if the activity of the $^{241}_{95}\text{Am}$ it contains drops below $\frac{1}{500}$ of its initial activity. How long will this smoke detector work? [3 marks]

Continued...

Question 5

(a) Given that 4.0 g of steam at 100.0 °C condenses to water on a burn victim's skin and cools to 45.0 °C. It is known that the specific heat of water and human tissue are 4186 J/kg.K and 3500 J/kg.K, respectively, and the latent heat of water is 2.256×10^6 J/kg.

(i) Determine the amount of heat given up by the steam. [1.5 marks]

(ii) If the skin was originally at 37.0 °C, calculate the tissue mass that was involved in cooling the steam to water. [1.5 marks]

(b) In an engine, an ideal gas is compressed adiabatically to half its volume. In doing so, 2500 J of work is done on the gas.

(i) How much heat flows in or out of the gas? [1 mark]

(ii) What is the change in internal energy of the gas? [2 marks]

End of Page

Physical Constants

Acceleration due to gravity	g	=	$9.8\ \text{m s}^{-2}$
Speed of Sound in Air	v	=	$343\ \text{m s}^{-1}$
Speed of light in vacuum	c	=	$3 \times 10^{8}\ \text{m s}^{-1}$
Threshold of hearing	I_o	=	$1.0 \times 10^{-12}\ \text{W m}^{-2}$
Coulomb constant	k	=	$9.0 \times 10^{9}\ \text{N m}^{2}\ \text{C}^{-2}$
Electronic charge	e	=	$1.602 \times 10^{-19}\ \text{C}$
Electron mass	m_e	=	$9.11 \times 10^{-31}\ \text{kg}$
Proton mass	m_p	=	$1.6726 \times 10^{-27}\ \text{kg}$
Neutron mass	m_n	=	$1.6749 \times 10^{-27}\ \text{kg}$
Refractive index of air/vacuum	n	=	1.0
Wein's displacement constant		=	$0.2898 \times 10^{-2}\ \text{m.K}$
Planck's constant	h	=	$6.626 \times 10^{-34}\ \text{J. s}$
Rydberg constant	R_H	=	$1.097 \times 10^{7}\ \text{m}^{-1}$
Avogadro's Number	N_A	=	$6.02 \times 10^{23}\ \text{mol}^{-1}$
Unified atomic mass unit	1 u	=	$1.66 \times 10^{-27}\ \text{kg}$
	1 eV	=	$1.602 \times 10^{-19}\ \text{J}$
Threshold of intensity of hearing	I_o	=	$1.0 \times 10^{-12}\ \text{Wm}^{-2}$
Stefan-Boltzmann constant	σ	=	$5.67 \times 10^{-8}\ \text{J s}^{-1}.\text{m}^{-2}.\text{K}^{-4}$
Universal gas constant	R	=	$8.31\ \text{J mol}^{-1}\ .\ \text{K}^{-1}$
Boltzmann's constant	κ	=	$1.38 \times 10^{-23}\ \text{J K}^{-1}$
	1 atm	=	$1.013 \times 10^{5}\ \text{Pa}$

The energy equivalent of the atomic mass unit is 931.5 MeV

Formula List

$\sin\theta_1 + \sin\theta_2 = 2\sin ½(\theta_1+\theta_2)\cos ½(\theta_1-\theta_2)$

$\cos\theta_1 + \cos\theta_2 = 2\cos ½(\theta_1+\theta_2)\cos ½(\theta_1-\theta_2)$

$\sin\left(\theta+\frac{\pi}{2}\right)=\cos\theta$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angle

$D(x,t) = D_M \sin(kx \pm \omega t \pm \phi)$

$v = \sqrt{\frac{F_\tau}{\mu}}$ $\quad$ $\mathrm{v} = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}}$

$\lambda_n = \frac{2}{n}L$ $\quad$ $f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$

$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f}$ $\quad$ $\frac{1}{f} = (n-1)\left\{\frac{1}{R_1}+\frac{1}{R_2}\right\}$

$d\sin\theta = m\lambda$ $\quad$ $d\sin\theta = \left(m+\frac{1}{2}\right)\lambda$

$\lambda_m.T = 0.2898 \times 10^{-2}$ $\quad$ $I(\lambda,T) = \frac{2\pi c k_B T}{\lambda^4}$

$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right)$ $\quad$ $r_n = \frac{\hbar^2}{mke^2}n^2$ $\quad$ $L = mvr_n = n\hbar$

$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2}-\frac{1}{n_f^2}\right]$ $\quad$ $\frac{1}{\lambda} = \frac{mk^2\,Z^2e^4}{4\pi\,c\hbar^3}\left[\frac{1}{n_f^2}-\frac{1}{n_i^2}\right]$ $\quad$ $\lambda = \frac{h}{p}$

$R = R_0 e^{-\lambda t}$ $\quad$ $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ $\quad$ $Q = (M_X - M_Y - M_\alpha)\,c^2$

$pV = nRT$ $\quad$ $k = \frac{R}{N_A}$

$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L}$ $\quad$ $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$ $\quad$ $\frac{\Delta Q}{\Delta t} = IeA\cos\theta$

$\overline{\mathrm{KE}} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $\quad$ $U = \frac{3}{2}nRT$

$Q = \Delta U + W$ $\quad$ $W = \int \mathrm{d}W = \int_{V_i}^{V_f} P\mathrm{d}V$